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Environmental Assessment of Coal Cleaning Processes: Selection of Test Sites for Source Test Program

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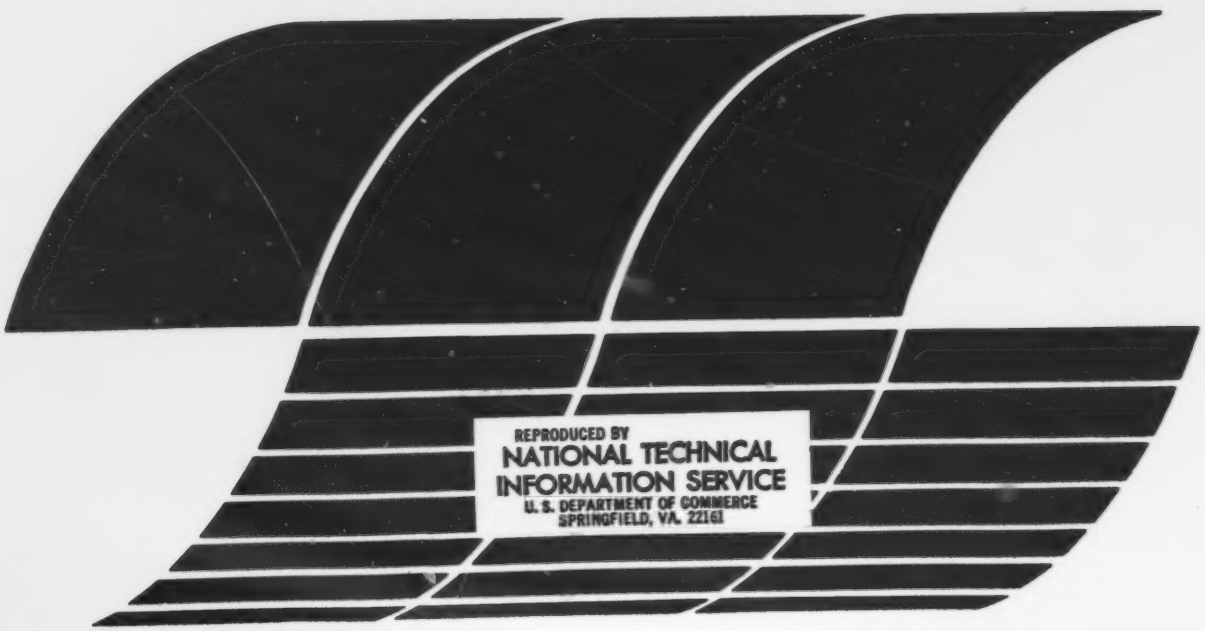

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16. ABSTRACT The report describes the selection of coal cleaning plants at which field testing and sampling will be conducted to support the environmental assessment of the pollution potential of various coal cleaning processes. The approach was to select a few plants (representing extremes in variables considered important in evaluating the pollution potential of these types of plants) from which data may be obtained. Site selection involved: (1) classifying plants into a number of site categories; and (2) gathering additional detailed information on specific plants and applying secondary constraints to a single suitable site for sampling in each site category identified in step (1). Step (1) assumes that all sites are equal within each category; in step (2), however, the best or most representative site within a category is to be selected. Classifying plants into various site categories is based on four criteria (variables): the acid neutralization potential of the soil surrounding the plant, the pyritic sulfur content of run-of-mine coal, the average annual precipitation, and the process technology. An initial sorting of the more than 400 known coal cleaning plants produced lists of plants which correspond to each of the 10 site categories. Imposing constraints reduced the number of potential test sites to 45. Site visits, to acquire additional information, are necessary before the final sampling sites can be selected.

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Test Facilities	Coal Cleaning	14B
Sampling	Soil pH	
Soil Chemistry	Pyritic Sulfur	08G,02A
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FOREWORD

Many elements and chemical compounds are known to be toxic to man and other biological species. However, our knowledge concerning the levels and conditions under which these substances are toxic is extremely limited. Little is known concerning the emission of these pollutants from industrial processes and the mechanisms by which they are transported, transformed, dispersed, or accumulated in our environment.

Portions of the Federal Clean Air Act, the Resource Conservation Recovery Act, and the Federal Water Pollution Control Act require the U.S. Environmental Protection Agency (EPA) to identify and regulate hazardous or toxic substances which result from man's industrial activities. Industrial pollutants are often identified only after harmful health or ecological effects are noted. Remedial actions are costly, the damage to human and other biological populations is often irreversible, and the persistence of some environmental contaminants may endanger future populations.

EPA's Office of Research and Development (ORD) is responsible for health and ecological research, studies concerning the transportation and fate of pollutants, and the development of technologies for controlling industrial pollutants. The Industrial Environmental Research Laboratory, an ORD organization, is responsible for development of pollution control technology and conducts a large environmental assessment program. The primary objectives of this program are:

- The development of information on the quantities of toxic pollutants emitted from various industrial processes--information needed to prioritize health and ecological research efforts.
- The identification of industrial pollutant emissions which pose a clearly evident health or ecological risk and which should be regulated.
- The evaluation and development of technologies for controlling pollution from these toxic substances.

The coal cleaning environmental assessment program has as its specific objectives the evaluation of pollution and pollution control problems which are unique to coal preparation, storage, and transportation. The coal preparation industry is a mature yet changing industry and in recent years significant achievements have been made in pollution abatement.

In focusing on the effectiveness and efficiency of coal cleaning processes as methods of reducing the total environmental impact in the use of energy derived from coal, this report deals with the selection of sites at which experimental measurements will be performed. The information derived will be used for the environmental source assessment of physical coal cleaning facilities.

ABSTRACT

The objective of this subtask is to select coal cleaning facilities on which field testing and sampling programs will be conducted in support of the overall program directed at making an environmental assessment of the pollution potential of various coal cleaning processes. The approach developed has been to select a small number of coal cleaning plants from which data may be obtained. The plants have been selected to represent extremes in variables considered important in evaluating the pollution potential of these types of facilities.

The site selection procedure developed here consists of two steps. The first classifies coal cleaning plants into a number of site categories and identifies a sampling sequence for these categories. The second consists of gathering additional detailed information on specific plants and applying secondary constraints as a means of selecting a single suitable site for sampling within each of the site categories identified by the first step. In the first step it has been assumed that all sites are equal within each category; in the second step, however, the best or most representative site within a category is to be selected.

The classification of coal cleaning facilities into various site categories has been based on four criteria. These criteria are represented by four variables: (1) acid neutralization potential of the soil surrounding the facility, (2) pyritic sulfur content of run-of-mine (ROM) coal, (3) average annual precipitation, and (4) coal cleaning process technology. Taking these variables in combinations as extremes, high and low levels for each, there are 16 possible combinations; however, six do not occur for actual sites (e.g., high pyritic sulfur content of ROM coal does not occur in combination with low average annual precipitation).

Since the variable of coal cleaning process technology did not fall naturally into a high and low range, it was necessary to select the kinds of cleaning processes that would be studied. Therefore, coal preparation was classified into four levels according to the coal sizes being washed. For the site selection process, it was decided that Level 1 and 2 facilities, which wash the coarse coal sizes only, would constitute low (simple) technology, while Level 4 facilities, which wash the very finest coal sizes, would constitute high (complex) technology.

Using statistical principles, a sampling sequence for the ten available site categories was established so as to give first priority to investigation of main effects of a single variable and second priority to investigation of interactive effects of variables. The rankings of priority were based on answers to the following questions:

If only one site category were to be sampled, which combination of variables should it represent?
If two site categories were to be selected, which combination should be second?

This procedure was followed for all of the ten site categories.

The selection of sites within each site category will be accomplished by imposing a series of constraints to assure that specific kinds of questions are answered about pollution potential and pollution control for the coal cleaning processes. These contraints are grouped in order of importance as being primary, secondary, or tertiary in importance.

An initial sorting of the more than 400 known coal cleaning plants, using information available in the literature, produced lists of facilities which correspond to each of the ten site categories. For categories which included a large number of cleaning plants three secondary constraints were imposed that eliminated plants considered undesirable from a field sampling viewpoint. These abbreviated lists include a total of 47 facilities. Site visits need to be made to those listed facilities with cooperative management to obtain information not available in the literature. This information is required before a final selection of sampling sites can be made.

TABLE OF CONTENTS

	Page
FOREWORD	ii
ABSTRACT	iii
ACKNOWLEDGEMENTS	viii
INTRODUCTION	1
EVOLUTION OF SITE SELECTION PROCEDURE	3
RECOMMENDED PROCEDURE	5
Selection and Definition of Variables	5
Low and High Levels for Each Classification Variable	9
Site Categories	11
Complete Factorial Listing	11
Sequential Sampling Procedures	12
A Statistical Rationale for Sequential Sampling	13
Recommended Procedure for Selection of Site Categories	13
Recommended Sampling Design	14
Assessments of the Recommended Sampling Design	14
Conditional Main Effects	16
Conditional Interaction Effects	16
Some Limitations	19
Crude Benefit/Cost Ratios	20
A Review of the Optional Sampling Plans	20
Ranking by Panel Members	23
Site Selection	23
Primary Constraints Classed as Essential	25
Secondary Constraints	25

TABLE OF CONTENTS
(Continued)

	Page
Tertiary Constraints	27
Potential Sampling Locations	28
Information Needed for Final Site Selection	31
REFERENCES	32

APPENDIX A

LISTS OF CANDIDATE SAMPLING SITES BY SITE CATEGORY	33

APPENDIX B

COAL PREPARATION PLANT INFORMATION FORM	47

LIST OF TABLES

		Page
1.	Generic Types of Coal Preparation Plants	8
2.	Classification Variables and Associated Levels Used to Define Site Categories	10
3.	Factorial Listing of Site Categories	10
4.	Recommended Sequential Sampling Design for Coal Cleaning Plants	15
5.	Conditional Main Effects and Conditional Interactions Associated with the Recommended Sampling Design	18
6.	Crude Benefit/Cost Ratios	21
7.	Final Site Selection Procedures, Use of Prioritized Constraints	24
8.	Ranking of Pollution Control Technology for Cleaning Plants and their Associated Refuse Disposal Areas	26
9.	Summary of Potential Sampling Locations by Site Category	29
A-1.	Candidate Sites for Site Category 1 (1111)--Pennsylvania	35
A-2.	Candidate Sites for Site Category 2 (1110)--Ohio	37
A-3.	Candidate Sites for Site Category 3 (1011)	38
A-4.	Candidate Sites for Site Category 4 (0111)-- Kentucky (Western)	40
A-5.	Candidate Sites for Site Category 5 (1010)	41
A-6.	Candidate Sites for Site Category 6 (0110)	42
A-7.	Candidate Sites for Site Category 7 (0011)	43
A-8.	Candidate Sites for Site Category 8 (0010)	44
A-9.	Candidate Sites for Site Category 9 (0001)	45
A-10.	Candidate Sites for Site Category 10 (0000)	46
B-1.	Coal Preparation Plant Information Form	49

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INTRODUCTION

Battelle's Columbus Laboratories has contracted with the Industrial Environmental Research Laboratory, Research Triangle Park, (IERL-RTP), North Carolina, of the U.S. Environmental Protection Agency (EPA) to perform an environmental assessment of coal cleaning processes. The broad objective of Battelle's program with EPA is to perform a comprehensive assessment of the environmental pollution potential resulting from coal cleaning (physical and chemical), transportation, storage, and refuse disposal. In addition, combined techniques to achieve environmental goals, such as coal cleaning with stack gas scrubbing to reduce the pollution potential of coal-fired power plants, will be evaluated. Increased use of both physical and chemical coal cleaning techniques for the removal of sulfur and ash-forming constituents is of paramount importance in an era of growing dependance on coal as a major domestic source of energy. The advantage of coal cleaning processes is the removal of sulfur, ash, and a variety of other unwanted materials from the raw coal prior to any oxidation or reduction reactions.

In order to optimize the overall control of emissions from plants that use coal, it is necessary to assess the pollution potential of coal cleaning processes, allied operations, and -- in certain cases-- the end uses of coal. This optimization process will also include an economic evaluation of the benefits derived from coal cleaning, e.g., reduced cost of coal and ash transportation, simplified boiler design, less boiler downtime, smaller dust collectors and ash-disposal systems, and reduced costs for SO_2 control.

The broad goal of this program is to establish a strong base of engineering, ecological, pollution control, and cost data which can be used to determine which coal cleaning processes or pollution abatement devices are most acceptable from both an environmental and economic viewpoint. This information could also be used to identify needs for the development of new or improved pollution control technology.

In support of the broad goal stated above, a subtask has been established to select several coal cleaning facilities, for evaluation of their pollution potential. This evaluation will involve sampling of process and effluent streams for laboratory analysis using the EPA Phased Approach.

A variety of selection schemes theoretically could be applied to determine categories appropriate for study sites. Because the complexity of the technology employed at a coal cleaning facility is dictated by both the raw coal and the desired product, a number of possible schemes dealing with a variety of variables were examined prior to selecting the scheme presented in this report. The selection schemes examined ranged from simple random selection from the approximately 480 coal cleaning facilities by a single variable (i.e., geographic area) to more complex approaches dealing with sophisticated multivariate statistical techniques, such as permutation design or fractional factorial design. Basic treatment of the selection schemes considered may be found in Hansen et al.[1], Cochran and Cox[2], and Snedecor and Cochran[3]. Examination of this full array of schemes allowed selection of the approach that would limit the number of sites necessary for the environmental assessment and yet assure examination of the major variables thought to influence the pollution potential of a facility.

In the final development of an effective site-selection procedure, several constraints were imposed to assure that the requirements of the overall environmental assessment program would be satisfied and the program would be cost effective. These constraints resulted, in part, from a decision to select plants which represented extremes (high and low) in values of the variables to be tested (for example, pyritic sulfur levels, environmental settings, and various kinds of coal cleaning and pollution control technologies employed) rather than average or typical conditions. It was felt, that by examining the extremes in the variables, it would be possible to investigate the contribution of each individual variable in affecting the total environmental burden imposed by the cleaning of coal.

This report delineates the selection procedure, presents the statistical rationale in support of this procedure, and gives a preliminary listing of candidate sites for the environmental assessment of coal cleaning.

EVOLUTION OF SITE SELECTION PROCEDURE

There are over 400 coal cleaning plants listed in the 1977 Keystone Coal Industry Manual[4], ranging in application of technology from simple crushing and screening operations to sophisticated systems which clean and recover very fine coal. Because the number of plants from which to choose test sites is very large and because these potential test sites represent a wide variety of coal types, environmental settings, and cleaning processes, early in the program it was decided that the selection procedure should consist of two steps: (1) classification of the plants into groups and subsequent reduction of large groups to a manageable size by imposing constraints associated with data available in the literature, and (2) final selection of sampling sites from each group based on information obtained during site visits.

In the first scheme proposed (not ulitmately utilized) for plant classification, the variables were based mainly on differences occurring as a consequence of geographical location. These variables were applied in sequence. The first variable was acid or alkaline mine drainage as defined in the effluent guidelines report.[5] (Here the term "acid mine drainage" is also used to describe the water component of coal cleaning process streams.) This divided the U.S. into two areas: an acid area which comprised northern Appalachia and an alkaline area which comprised the rest of the country. This was in agreement with the system described in the effluent guidelines report.[5] The second variable was average annual precipitation. This further divided the alkaline area into southern Appalachia and Alabama (high rainfall), the Midwest (intermediate rainfall), and the West (low rainfall). Each of these areas was then divided according to the low and high pyritic sulfur content of the coals produced. This division did not affect the southern Appalachian, Alabama, or western areas since none of them report high-pyrite coals. At this point there were six plant categories.

Each of these plant categories was then divided into three groups according to complexity of the coal cleaning process, using the Stages I, II, and III processes as defined in the effluent guidelines report.[5]

Using this system, the variables produced 18 categories into which coal cleaning facilities might be classified. Unfortunately, the system requires the inclusion of all categories in any evaluation in order to produce any statistically rigorous evaluation of coal cleaning. The problem associated with the above selection scheme is that it cannot tolerate an incomplete design for site sampling without significantly affecting the results. Preliminary evaluation of sites for this scheme revealed that facilities did not exist in all categories; thus this approach failed. Other forms of this scheme were evaluated during the selection process, such as assigning numerical values to the variables, or introducing other variables such as plant production capacity, but the basic problem remained and thus this approach to site selection was abandoned.

A new scheme was then devised for the classification step of the site selection procedure. This scheme employed the same variables as the previous scheme and assigned two levels of each (high and low). These variables were then considered in combination rather than applied sequentially. When these four variables were considered each at two levels, 16 possible combinations were produced of which only 10 exist in the U.S. Each of the coal cleaning plants was then to be classified into one of these existing four-variable combinations and at least one plant from each group was to be included in the field program.

This scheme has had to be modified and refined through a number of stages to tailor it to fit the specialized needs of the program. One of the most important innovations was the creation of a panel consisting of nine Battelle researchers who are active in coal cleaning technology and related environmental research. The job of the panel was to rank the 16 possible combinations according to what they perceived as the potential of each to produce environmental impacts and then to assign numerical ratings to each rank. This scheme was an attempt to make selections on a system which would confound subjectivity as much as possible and be statistically defensible. The panel members worked independently and the results were tabulated and compared. Agreement among panel members was not very good, possibly because each considered his own special interest, and this approach was abandoned. However, the idea of having a panel make the evaluations was good, not only because it brought in the experience from several disciplines, but also because it tended to confound each member's personal biases. Consequently, the panel was retained and their opinions were used as the site selection procedure developed.

RECOMMENDED PROCEDURE

The site selection procedure consists of two steps. The first step consists of classifying coal cleaning plants into site categories and identifying the sampling sequence; i.e., which site category is to be sampled first, second, etc. This step includes gathering information from the literature on all plants listed and applying constraints relevant to the available data to eliminate plants considered undesirable for field sampling. This first step has been successfully accomplished, and the results are described below. The second step is to gather detailed information from plant management for the plants on the abbreviated lists and apply additional constraints to select the most suitable sampling site within each of the site categories. The constraints used in both steps are defined below.

Selection and Definition of Variables

The purpose of the initial step is to classify coal cleaning plants into groups that are as much alike as possible in selected characteristics, but with the differences among the groups representing the ranges of each of those characteristics. The environmental and process characteristics desired to be tested led to the selection of the variables, which were combined to establish the original 16 possible combinations. These variables were chosen by the panel as those having the greatest influence on the kinds of pollution controls needed for coal cleaning operations. The number of variables was limited to four to keep the combinations to a manageable number. The number of combinations which result from considering each variable at two levels is equal to 2 raised to the power of the number of variables. Thus, with four variables there are 16 combinations and with five variables there are 32 combinations and so on. The four variables selected were

neutralization potential of soil surrounding the coal cleaning plants, pyritic sulfur content of ROM coal, average annual precipitation, and coal cleaning process technology. The reasons for selecting these are discussed below.

- Neutralization potential (N). This is related to the presence or absence of calcareous materials in the spoils, refuse, and soil which can neutralize acid wastewater and is most easily measured as soil pH. As such, the concept transcends that of acid or alkaline mine drainage, though geographically they fall in the same areas. The intent here is to consider the capacity of the natural environment to absorb and counteract the impact of acid wastewaters. Thus, a high level of N constitutes a low pollution potential.
- Pyritic sulfur content of ROM coal (S). Areas of both high and low neutralization potential produce coals which vary widely in their content of ash, sulfur, iron, and other metals. There is a high positive correlation between pyritic sulfur concentrations and other coal contaminants that have high pollution potential. Refuse piles are sources of heavy metals, iron, and acid-soluble leachates which are a continuing threat to environmental systems and water supplies.
- Average annual precipitation (R). Precipitation is the most important single factor in creating an environmental setting. Precipitation, particularly rainfall, is also the single environmental event most affecting the pollution potential from coal cleaning operations. It governs (1) rate of runoff from refuse and coal piles, (2) deposition of airborne contaminants, (3) erosion or dissolution of particulates and salts into natural waters, (4) sediment contaminant loading, and (5) acidification of soils and waterways.
- Coal cleaning process technology (T). Characteristics of the wastes from a coal preparation plant are highly dependent on the processes utilized, which are in turn dictated by the raw coal and final product. As processes become increasingly more complex

and finer fractions of the coal are cleaned and collected, the pollution potential changes because (1) complex plants frequently use thermal driers which are a source of gaseous and particulate air pollution, (2) there is greater opportunity during processing for the soluble pollutants to be contacted by a solvent, and (3) chemical additives are used in static thickeners and froth flotation cells, thus increasing the number of potential pollutants. Since this variable did not fall naturally in a high (complex) and low (simple) range, it was necessary to select the kinds of cleaning processes that would be studied. The kinds of unit operation combinations typically employed in different plant types are shown in Table 1. In order to provide a systematic method for selecting plants based on technology extremes, coal preparation has been classified into four levels according to the coal sizes being washed. The coal preparation plants are then categorized into nine generic types based on coal cleaning processes employed. These levels of preparation and types of plants are summarized in Table 1 and defined in more detail as follows:

- Level 1 - Crushing and Sizing
- Type A: Crushing for top size control with limited removal of coarse refuse and trash by scalping screen and/or rotary breaker.
- Level 2 - Coarse Size Coal Beneficiation

  Type B: Type A followed by dry screening at 3/8 inch and wet beneficiation of plus 3/8-inch material only with jig or dense-medium vessel. Minus 3/8-inch material is mixed with coarse product without washing. Simple mechanical dewatering for plus 3/8-inch material.
- Level 3 - Medium Size Coal Beneficiation

  Type C: Type B plus dry beneficiation of minus 3/8-inch material with air table.

TABLE 1. GENERIC TYPES OF COAL PREPARATION PLANTS

Level[a]	Plant Type	Coal Size and Unit Operation[b]		
		Coarse (3 x 3/8 in.)	Medium (3/8 in. x 28 M)	Fine (28 M x 0)
1	A	CS		
2	B	CS + J/DMV + MD		
3	C	CS + J/DMV + MD	← AT →	
3	D	CS + J/DMV + MD	← WT + MD →	
3	E	CS + J/DMV + MD	← DMC + MD →	
4	F	CS + J/DMV + MD	WT + MD	HC + MD + TD
4	G	CS + J/DMV + MD	WT + MD	F + MD + TD
4	H	CS + J/DMV + MD	DMC + MD	HC + MD + TD
4	I	CS + J/DMV + MD	DMC + MD	F + MD + TD

(a) Level 1 - Crushing and Sizing
Level 2 - Coarse Size Coal Beneficiation
Level 3 - Medium Size Coal Beneficiation
Level 4 - Fine Size Coal Beneficiation

(b) CS - Crushing and Sizing Devices
J - Jigs
DMV - Dense-Medium Vessels
DMC - Dense-Medium Cyclones
AT - Air Tables
WT - Wet Concentrating Tables
HC - Hydrocyclones
F - Froth Flotation Units
MD - Mechanical Dewatering Devices
TD - Thermal Dryers

Type D: Type A followed by wet screening at 3/8 inch and Type B beneficiation of minus 3/8-inch material with concentrating table.

Type E: Same as Type D except that heavy-medium cyclone is used for minus 3/8-inch material beneficiation.

- Level 4 - Fine Size Coal Beneficiation

Type F: Type D followed by wet beneficiation of minus 28-mesh material with hydrocyclones. Thermal drying for fine coal product.

Type G: Same as Type F except that froth flotation circuit is used for minus 28-mesh material beneficiation.

Type H: Type E followed by wet beneficiation of minus 28-mesh material with hydrocyclone. Thermal drying for fine coal product.

Type I: Same as Type H except that froth flotation circuit is used for minus 28-mesh material beneficiation.

The two levels of plant types selected from Table 1 to represent technology extremes are (1) Level 1 which represents a simple (low) technology group including plant types A and B, and (2) Level 4 which represents a complex (high) technology group including plant types F, G, H, and I*. Process stream samples representative of the other plant types can be obtained, if desired, by sampling upstream of specific unit operations or pollution control devices.

Low and High Levels for Each Classification Variable

To better identify suitable site categories, two levels for each of the N, S, R, and T variables have been defined. Table 2 lists the classification variables and their associated low (0) and high (1) levels.

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* This selection was made based on the complexity of the technology used and not necessarily on degree of pollution potential. Level 3 facilities, for example, may have the greatest pollution potential, since they make no attempt to incorporate the fine-fines (28M x 0) back into their product.

TABLE 2. CLASSIFICATION VARIABLES AND ASSOCIATED LEVELS USED TO DEFINE SITE CATEGORIES

Variable	Low Level(0)	High Level(1)
N (Neutralization potential)	pH $\geq$ 7.5[a]	pH $\leq$ 6.0[a]
S (pyritic sulfur)	$\leq$ 1.0%	$\geq$ 2.0%
R (average annual rainfall)	$\leq$ 15 in./yr	$\geq$ 25 in./yr
T (coal cleaning process technology)	Plant Types A & B[b]	Plant Types F, G, H. I[b]

(a) pH of soil in the receiving environment. As defined, low N actually refers to a low pollution potential or high soil alkalinity which is, in fact, a high ability to neutralize acid streams.

(b) See page 7 for definitions of plant types.

TABLE 3. FACTORIAL LISTING OF SITE CATEGORIES

(N,S,R,T)[a]	(N,S,R,T)
(1111)	(0111)
(1110)	(0110)
(1101)[b]	(0101)[b]
(1100)[b]	(0100)[b]
(1011)	(0011)
(1010)	(0010)
(1001)[b]	(0001)
(1000)[b]	(0000)

(a) See Table 2, above, for definitions of low (0) and high (1) levels of pollution potential as expressed by neutralization potential, N; pyritic sulfur, S; average annual rainfall, R; and coal cleaning process technology, T. The combination (1010), for example, denotes a site category with N and R at Level 1 and S and T at Level 0.

(b) Site categories marked with an asterisk are excluded from further consideration, since no cleaning plants exist with these combinations of variables.

The low and high levels are intended to reflect relatively small or large pollution potentials, respectively, for the first three variables and simple or complex process technology. Thus, (0) indicates low sulfur and rainfall but high neutralization potential. It should be noted that intermediate ranges of N, S, R, and T have been excluded in the definitions of low and high levels. This means that the sites ultimately selected will have relatively extreme values (low or high) for the classification variables. Such sites are desired in order to reflect the range of possible conditions among coal cleaning plants, and are neither expected nor intended to be "statistically representative" or "typical" with respect to the population of coal cleaning sites.

Site Categories

On the basis of low (0) and high (1) levels for each variable shown in Table 2, a site category can be represented by an ordered sequence, such as (0110) for N, S, R, and T, respectively. Such a sequence represents a site category characterized by a neutralization potential, N, at Level 0; pyritic sulfur, S, at Level 1; annual rainfall, R, at Level 1; and process technology, T, at Level 0. Each four-component vector, consisting of zeros and ones, serves to identify a particular combination of low and high levels for the classification variables N, S, R, and T.

Complete Factorial Listing

With the two levels defined for each of the four variables, N, S, R, and T, a complete factiorial listing of the 16 conceptually possible combinations of levels can be generated.

The 16 combinations of low and high levels are listed in Table 3. (Page 10) The combinations marked with an asterisk denote site categories that were subsequently excluded from consideration. It is seen that the excluded categories are all associated with low rainfall (R=0) and are therefore represented by western sites. Four of these site categories (0100), (0101), (1100), and (1101) have relatively high sulfur (S=1) and high sulfur is not characteristic of western coal. The combination of low rainfall and

high sulfur is taken to be an inconsistency and is the basis for exclusion of these four categories from the list. In a similar manner, the site categories (1000) and (1001) are excluded from the list because the low level of neutralization potential (N=1) is not characteristic of low rainfall (R=0) western sites. The remaining ten site categories are subsequently examined to assess their relative importance.

Sequential Sampling Procedures

Sequential sampling procedures are often appropriate in those settings where time or cost constraints may cause the sampling procedure to be terminated prior to the sampling of all units. In the context of sampling coal cleaning plants, for example, it is possible that sufficient resources may not be available to permit sampling at ten different sites, with one site selected from each of the ten site categories. In this setting one could raise the following questions: If only one site category could be sampled, which would it be? If an additional site category could then be sampled, which would it be? This could be applied for all ten site categories. Clearly, it would be desirable to sample ten different sites, one from each of the ten site categories. However, to protect against the possibility that this cannot be done, it is prudent to identify an optimal sampling sequence. The optimal sequence would be one wherein the sites providing the most desired information are sampled early in the sampling program, with the sites yielding the less desired information being scheduled for sampling later in the program. This procedure would permit the most desired information to be obtained even though the sampling is terminated before all sites have been sampled.

In the statistical literature, sequential sampling designs based on factorial combinations, as shown in Table 3, are usually called one-factor-at-a-time designs. These designs have been examined by Webb[6] as a contractible permutation invariant design and by Rechtschaffner[7] as a saturated fractional factorial. The design is said to be contractible because the sequence of tests can be stopped after specified groups of tests have been run; the design is saturated because no degrees of freedom are available for estimating error.

A Statistical Rationale for Sequential Sampling

A basic statistical rationale for identifying sampling sequence for factorial designs may be stated as follows:

- Early in the sampling sequence, sample those site categories that permit the "main effect" of each classification variable to be investigated; next include those site categories that permit investigations of the "interaction effect" associated with two classification variables, then three classification variables, etc.

This rationale is based on the assumption that the most desired information is that associated with the main effects of single variables. After obtaining information on the effect of each classification variable, the next priority is then associated with information on the combined effects of two classification variables, etc.

Recommended Procedure for Selection of Site Categories

For the selection of site categories Battelle recommends that a sequential sampling procedure for factorial designs be used, with the investigation of main effects of single variables given first priority and interaction effects among pairs of variables given second priority.

In comparison with the designs discussed in the literature, the sampling designs resulting from this procedure are unavoidably degraded by the deletion from the factorial listing of the six site categories in which cleaning plants do not exist. A complete factorial design, consisting of all 16 possible site categories, would permit the consideration of all possible unconditional main effects and interactions of variables. As discussed below, the degraded design permits only certain conditional main effects and interactions to be considered. Nevertheless, the following discussions show that the degraded design retains a number of desirable statistical properties, and it is generally supported by individual, independent evaluations made by the nine panel members.

Recommended Sampling Design

Battelle has applied the procedure recommended above to the selection of site categories. The application was made among the ten existing site categories represented by the factorial listing shown in Table 3.

The sequential sampling design for the ten coal cleaning site categories resulting from the site selection procedure is shown in Table 4. The table shows three sampling groups of site categories. The first group to be sampled consists of four site categories: (1111), (1110), (1011), and (0111). Site Category (1111) represents the "worst" case with all four classification variables at high levels of pollution potential. Group 2 would be sampled next and consists of four site categories. Group 3 would be sampled last and consists of two low-rainfall, western site categories. The geographic regions associated with the site categories are shown in the last column as Northern Appalachia (NA), Southern Appalachia (SA), the Midwest (MW), Alabama (A), and the West (W).

The recommended sampling design calls for sites to be sampled in the sequence 1 through 10 as shown in Table 4. On the basis of the statistical rationale described above, the sites within each of the three groups may be sampled in any order. However, on the basis of engineering judgment, Battelle recommends the exact sampling order for each group indicated in Table 4. Further justification for this sampling order is given following a more detailed discussion of the statistical properties of the recommended sampling design.

Assessments of the Recommended Sampling Design

As noted above, the recommended selection procedure for site categories assigns first priority to investigation of single-variable main effects, followed by investigation of two-variable interaction effects. Because of the limited number of site categories, these main effects and interactions are conditional (rather than unconditional). The following discussion makes those conditions explicit.

TABLE 4. RECOMMENDED SEQUENTIAL SAMPLING DESIGN FOR COAL CLEANING PLANTS

Group Number	Site Category[a]	Site Characteristics (N, S, R, T)[b]	Regions[c]
1	1	(1111)	NA
	2	(1110)	NA
	3	(1011)	NA
	4	(0111)	MW
2	5	(1010)	NA
	6	(0110)	NA
	7	(0011)	MW, SA, A
	8	(0010)	MW, SA, A
3	9	(0001)	W
	10	(0000)	W

(a) One site from each category is to be sampled in the sequence from 1 through 10, with Site Category 1, defined as (1111), sampled first and Site Category 10, defined as (0000), sampled last. The sampling may be terminated after sampling four site categories (Option C), eight site categories (Option B), or ten site categories (Option A).

(b) See Table 2, page 10 for definitions of low (0) and high (1) levels for neutralization potential, N; pyritic sulfur, S; average annual rainfall, R: and coal cleaning process technology, T. The combination (1010), for example, denotes a site category with N and R at Level 1 and S and T at Level 0.

(c) Regions associated with the site categories are denoted by Alabama (A), Northern Appalachian (NA), Southern Appalachian (SA), Midwest (MW), and West (W).

Conditional Main Effects. To obtain information on the main effects of neutralization potential, for example, data from two sites must be compared, with one site having relatively good and one site having relatively poor neutralization potential; the comparison sites should be "matched" with regard to their levels of sulfur, rainfall, and technology. Such a comparison yields a conditional main effect. The word "conditional" is used to highlight the fact that a main effect of N is determined under the conditions specified by the levels for S, R, and T.

To indicate how the recommended sampling procedure generates conditional main effects, note that the first two site categories, (1111) and (1110), are matched with respect to the levels of N, S, and R. In particular, N, S, and R are each at level 1 for both site categories. The site categories differ only with respect to the levels of technology, T. Thus, the sampling results from the sites selected from those two site categories would permit differences attributable to technology to be investigated. Such differences would be labeled as conditional main effects of technology given relatively matched, high level conditions for N, S, and R. These conditional main effects are denoted by the symbol (111T). In a similar manner, after a site from Site Category 3 is sampled, conditional main effects of sulfur would be obtained by comparing data from Site Category (1011) with data obtained from Site Category (1111). This would yield conditional main effects of sulfur, given relatively matched, high levels for N, R, and T, and is represented by the symbol (1S11). Similarly, after sampling Site Category 4, a conditional main effect for N, given high levels for S, R, and T, would be obtained by comparing results obtained from sites selected from Site Categories (0111) and (1111) to give (N111). In this way, it is seen that after sampling one site from each of the first four site categories--1,2,3,4 of Table 4--a conditional main effect could be investigated for N, S, and T under the condition that all matched variables are at relatively, high levels.

To summarize, Option C (see footnote (a) to Table 4) of the recommended sampling procedure is intended to yield data that will permit conditional main effects of N, S, and T to be investigated, under the condition that all matched variables are at relatively high levels.

Conditional Interactive Effects. Some of the effects related to combined changes in the levels of two variables can also be investigated by

means of the recommended sampling design. For example, after sites from the first five site categories shown in Table 4 have been sampled, comparisons among results obtained for Site Categories 1, 2, 3, and 5 will permit investigations to be made of conditional interactions between technology and sulfur (TxS) with both N and R at high (1) levels. To see this, it is necessary to note only that in these site categories- (N, S, R, T) = [(1111), (1110), (1011), and (1010)]- the levels of N and R (first and third positions) are all equal to 1, whereas the levels of S and T (second and fourth positions) take all possible combinations of levels: (11), (10), (01), and (00).

It should also be noted that after Site Category 5 has been sampled, a second conditional main effect of technology may be investigated by comparing the results obtained from Site Category 5, (1010), with the results obtained from Site Category 3, (1011). This comparison yields a main effect of technology given that N, S, and R have levels 1, 0, 1, respectively. At this stage of the sampling procedure, the two resulting conditional main effects of technology are symbolized by (111T) and 101T).

It can be seen that there are eight conceptually possible conditional main effects for technology, associated with the eight possible combinations of zeros and ones for the first, second, and third positions of the symbol (xyzT). Theoretically, the average of these eight conditional main effects would give the unconditional main effect of technology. However, because six of the 16 conceptually possible combinations do not represent actual coal cleaning sites, unconditional main effects cannot be obtained from the sampling procedure. More generally, it should be noted that the sampling procedure can yield only conditional main effects and interactions. Because there are many possible conditions associated with each main effect and interaction, the exact condition must be explicitly indicated.

Table 5 summarizes the conditional main effects and interactions that may be investigated as data are successively obtained from Site Categories 1 through 10, as required by the recommended sampling designs. As shown in the table, no main effects or interactions are obtained from sampling at Site Category 1 (1111). After sampling from Site Category 2 (1110), a conditional main effect of technology, T, given that N,S, and R are all at Level 1, is obtained by comparing results for Sites 1 and 2, as shown by the last column in Table 5. This conditional main effect is symbolized in

TABLE 5. CONDITIONAL MAIN EFFECTS AND CONDITIONAL INTERACTIONS ASSOCIATED WITH THE RECOMMENDED SAMPLING DESIGN

Group Option	Site Category[a]	Conditional Effects	Conditions[b] (N,S,R,T)	Comparison of Categories[c]
C	1(1111)	--	(1111)	--
	2(1110)	T	(111T)	1,2
	3(1011)	S	(1S11)	1,3
	4(0111)	N	(N111)	1,4
B	5(1010)	T	(101T)	3,5
		S	(1S10)	2,5
		SxT	(1S1T)	1,2,3,5
	6(0110)	N	(N110)	2,6
		T	(011T)	4,6
		NxT	(N1IT)	1,2,4,6
	7(0011)	N	(N011)	3,7
		S	(0S11)	4,7
		NxS	(NS11)	1,3,4,7
	8(0010)	N	(N010)	5,8
		S	(0S10)	3,5
		T	(001T)	7,8
		SxT	(0S1T)	4,6,7,8
		NxT	(N01T)	3,5,7,8
		NxS	(NS10)	2,5,6,8
A	9(0001)	R	(00R1)	7,9
	10(0000)	R	(00R0)	8,10
		T	(000T)	9,10
		RxT	(00RT)	7,8,9,10

(a) Obtained from Table 4.

(b) The symbol (1S10), for example, is ordered according to (N,S,R,T) and indicates that a conditional main effect of sulfur can be investigated, the condition being that N and R are at Level 1 and T is at Level 0. The two-variable interactions are indicated by symbols having two letters, so that (1S1T) indicates a conditional interaction between sulfur and technology given N and R are at Level 1.

(c) The entry 1,2,3,5 shown for (1S1T) indicates, for example, that a conditional interaction effect can be investigated by comparing results obtained from sites selected from Site Categories 1(1111), 2(1110), 3(1011), and 5(1010).

column 3 as (111T). Subsequent sampling of Site 3 then allows the conditional main effect of sulfur (1S11) to be obtained by comparing results for Sites 1 and 3, with N, R, and T at Level 1. Table 5 shows that after obtaining data from one site in each of the first four site categories conditional main effects for N, S, and T can be investigated.

The second group of sites is to be selected from Site Categories 5, 6, 7, and 8. The table shows that after sampling Site Category 5, a second conditional main effect for T (101T); a second conditional main effect for S (1S10); and a conditional two-variable interaction (1S1T) between sulfur and technology may be investigated. It should be noted that this two-variable interaction (1S1T) requires comparisons among data from the four site categories--1, 2, 3, 5--as shown in the last column of the table. In general, the table shows that, as sites are successively sampled, more and more conditional main effects and conditional interactions can be investigated.

Some Limitations. It is important to note that most of the statistical principles described above are strictly applicable to controlled experimentation performed in a laboratory. Such principles not only serve as a basis for defining experimental conditions (sampling design) but also provide appropriate methods for analysis of the resulting data. The sampling design and the method of data analysis are mutually dependent. The statistical properties of the sequential sampling design shown in Table 5 are discussed as though the recommended sampling of the coal cleaning plants were performed in a controlled laboratory environment. This, of course, is not the case. Many uncontrolled influences, such as recent weather conditions, may serve to contaminate the data obtained at the sampled sites. These uncontrolled influences would be expected to complicate the interpretation of measured differences between two sites.

As an example, suppose that a particular environmental measures are found to be markedly different for Site 1 (1111) and Site 2 (1110). According to Table 5, such a difference is a measure of the conditional main effect of technology (111T). However, such an interpretation may be totally erroneous because the difference, in fact, may have resulted from variables not controlled at the two sites. From this perspective it is seen that the only conditions at the two sites that are "controlled" are those condi-

tions associated with the "matched" levels of N, S, and R, and Table 2 shows that even those variables are only loosely constrained to lie in relatively broad "high" ranges.

These considerations indicate that the interpretation of every quantitative comparison involving different sites must be separately examined for validity. The recommended sequential sampling design does not, in itself, guarantee that such comparisons will yield valid measures of conditional main effects and interactions. The recommended sampling design simply serves to identify which conditional main effects and interactions should be investigated and which site comparisons are required to make such investigations.

Crude Benefit/Cost Ratios. A further assessment of the sampling design is provided by examining the average benefit/cost ratio as successive sites are sampled. These ratios may be crudely approximated by assuming a unit cost for sampling each site. It is also assumed that the benefits are measured by the number of main effects and interactions that can be investigated.

Table 6 shows the benefit/cost ratios based on the sampling sequence given in Table 4. The table shows an average benefit/cost ratio of 0.75 after the four sites of Option C have been sampled. This ratio increases to 2.25 after the eight sites of Option B have been sampled. A small decrease in the ratio occurs with the addition of the western sites of Option A because not many additional effects can be investigated by sampling these sites. This results from the previous exclusion of the six western site categories.

A Review of the Optional Sampling Plans

On the basis of the preceding discussion, a summary review of the sampling Options A, B, and C can be made. Option C consists of sampling one site from each of the first four site categories shown as Group 1 in Table 4. This option yields data on Site Category (1111) that has the potential for the greatest pollution severity. In addition, data on condi-

TABLE 6. CRUDE BENEFIT/COST RATIOS

Option	Cumulated Sampled Sites	Cumulated Benefits(a)	Cumulated Costs(b)	Average Benefit/Cost Ratio
C	1	0	1	0.00
	2	1	2	0.50
	3	2	3	0.67
	4	3	4	0.75
B	5	6	5	1.20
	6	9	6	1.50
	7	12	7	1.71
	8	18	8	2.25
A	9	19	9	2.11
	10	22	10	2.20

(a) Assumes that each conditional main effect and interaction shown in Table 5 is of unit benefit.

(b) Assumes unit cost for each sampled site.

tional main effects of technology, sulfur, and neutralization potential are obtained from this option. Although Option C provides information on separate conditional main effects for each of these classification variables, it does not provide any information on the combined effects of two classification variables. Such information is provided by Option B which involves sampling from Groups 1 and 2 shown in Table 4. In particular, under Option B, in addition to the information obtained from Option C, conditional interaction information is obtained for combined effects of sulfur and technology, neutralization potential and technology, and neutralization potential and sulfur. Option B also yields data on main effects of technology, sulfur, and neutralization potential under conditions different from those obtained under Option C. In addition to the three conditional main effects of Option C, Table 5 shows that Option B provides information on a total of nine conditional main effects and six conditional two-variable interaction effects. Option A consists of sampling sites from all ten site categories in Table 4. This option yields additional information on two conditional main effects of rainfall, a conditional main effect of technology, and a conditional interaction effect between rainfall and technology. The two additional site categories associated with Group 3 are placed at the end of the sequential sampling plan because: (1) Site Categories 9 and 10 require sampling at western sites for which unit cost may be greater than for the other site and (2) as shown in Table 5, the benefit/cost ratio passes through a maximum for the eight sites represented by Option B. In short, Option A yields the maximum information obtainable from the ten site categories; Option B yields over 80 percent of the possible conditional main effects and interactions, with the effects of rainfall excluded; and Option C yields information on the main effects of technology, sulfur, and neutralization potential.

There are several characteristics of western coal producing areas which are important to consider. Largely because of the low rainfall, the environment of the West is fragile; that is, it is easily damaged and slow to recover. With the expansion of coal production in that part of the country as predicted, the protection of that environment will be of increasing concern. In addition, there are metal constituents in western coals which differ from those in other parts of the country. Such things as uranium

as well as heavy metals (e.g., antimony, cadmium, and selenium) as effluent products should be considered.[8] Finally, the only opportunity to consider rainfall as a variable and study its effects as a part of this program is to include western sites. Option A is therefore recommended.

Ranking by Panel Members

The desirability of sampling at each of the ten site categories was independently assessed by each of the nine panel members. The agreement among the nine resulting rankings was assessed using Kendall's coefficient of concordance.[3] On a scale between 0 (no agreement) and 1 (perfect agreement), the panel rankings yielded a coefficient of concordance equal to 0.78 when the site categories were grouped into the three categories defined in Table 4. The concordance measure of 0.78 is taken to indicate a reasonable measure of agreement for the preference rankings of the three groups. However, considerable disagreement among panel members was found for the relative rankings of the site categories within the three groups. In short, the panel agreed on the overall rankings of the three groups but did not agree on the relative rankings within groups. The disagreement may be partly due to the differing technical specialties among the panel members.

Site Selection

The purpose of the following selection procedure is to provide a mechanism for selecting sites within each of the ten site categories by imposing a series of constraints. Abbreviated lists of candidate sites from each site category chosen by imposing some of these constraints are presented in Appendix A. These lists are based solely on information readily available in the literature and previous surveys of coal cleaning plants. Telephone contacts and site visits with plant management at sites which seem to be prime candidates for study will provide the additional information needed to make the final site selection from the abbreviated lists.

The constraints described below are not all equally binding and may be classified in order of importance as primary, secondary and tertiary as shown in Table 7. Plants are expected to be found which meet most, but not

all, of these constraints. Primary constraints are those essential criteria that must be met in order for a facility to be considered for the sampling program. Plants that also meet some of the secondary constraints will be considered highly desirable sampling locations, but the status of these constraints will not necessarily result in inclusion or exclusion of a facility from the list of sampling locations. If several plants can be found in a given site category which meet all of the primary and all or most of the secondary constraints, then the tertiary constraints will be imposed in the final selection of a facility for testing.

TABLE 7. FINAL SITE SELECTION PROCEDURES, USE OF PRIORITIZED CONSTRAINTS

Constraints
• Primary
(1) Most efficient pollution control technology
(2) Plant management cooperation
• Secondary
(1) Two ages of refuse piles
(2) Greater than mean plant capacity
(3) Baseline data available
• Tertiary
(1) Minimal coal industries in area
(2) Nonmixed refuse piles
(3) Uniform coal source

Primary Constraints Classed as Essential

Primary constraints are described as listed in Table 7.

(1) Most efficient pollution control technology. Since the overall goal is to assess pollution potential, we plan to assess the pollution loading of one of the coal cleaning facilities in each site category which is currently serving as a benchmark in pollution control technology for that particular type of coal cleaning process.

Selection of the facility within each site category which has the most efficient pollution control technology will be accomplished by using the ranking information in Table 8. After site visits have provided details on the pollution control technology at each site on the abbreviated lists, a score will be tallied on the basis of Table 8 and the number of points awarded for each type of pollution control technology as follows: (a) high efficiency techniques - 3 points, (b) medium efficiency techniques - 2 points, and (c) low efficiency techniques - 1 point. Facilities in each site category with the highest score (most efficient pollution control technique) will be given first priority in the final site selection process.

(2) Plant management cooperations. The willingness of plant management to let us carry out field studies is a necessity for a successful sampling and testing program.

Secondary Constraints

Secondary constraints are described as listed in Table 7.

(1) Two ages of refuse piles. These are required to initially discern the effects of leaching upon the area. One pile should be approximately 10 years old for these processes to be easily defined.

TABLE 8. RANKING OF POLLUTION CONTROL TECHNOLOGY FOR CLEANING PLANTS AND THEIR ASSOCIATED REFUSE DISPOSAL AREAS

Coal Cleaning Plants				Disposal Area for Cleaning Plant Refuse			
Air Pollution Control Technology		Water Pollution Control Technology		Air Pollution Control Technology		Water Pollution Control Technology	
Particulate Control Devices	Gaseous Pollutant Control Devices	Suspended Solids Control Devices	Dissolved Solids Control Devices	Fugitive Dust Control Techniques	Fire Control Techniques	Erosion Control Techniques	Leachate Control Techniques
High Efficiency							
Bag (fabric) filters Venturi scrubbers	SO_2 scrubbing system[a]	Closed loop using thickeners with flocculants	Closed process water loop	Sealing agent Soil covering Revegetation	Soil covering	Diversion ditches and siltration basins for runoff	Ion exchange treatment of leachate pond water[a] Reverse osmosis treatment of leachate pond water[a]
Medium Efficiency							
Self-induced scrubbers High-efficiency cyclones Impingement scrubbers Centrifugal scrubbers		Open loop using microscreen units, vacuum filters, settling ponds	Open process water loop with neutralization, aeration, and sedimentation	Compacting Low-wind-velocity location	Minimal grade of embankment Compacting Sealing agent	Compacting Soil covering	Leachate collection pond(s) with neutralization, aeration, and sedimentation Impervious liner for disposal area Dewater refuse slurries Grading refuse to promote runoff Revegetation
Low Efficiency							
Louver (gravity) settling chambers Conventional cyclones Water spray Dust enclosures	Venturi scrubbers Impingement scrubbers Centrifugal scrubbers Self-induced scrubbers	Open loop using centrifuges	Open process water loop with neutralization	Water spray	Water spray		Diversion ditches for Slurry impoundments Soil covering to minimize exposed refuse area

(a) Not presently in use at a coal cleaning facility.

(2) Greater than mean plant capacity. A plant selected from any site category will be one whose production capacity is greater than the mean capacity of the plants listed in that site category. Plant capacity is important for two reasons: larger plants have a greater pollution potential and are more likely to yield useful information on effectiveness of complex pollution controls and the greatest effects on ecosystems will result from these plants because of the volume of wastes.

(3) Baseline data available. The best way to determine the effects of coal cleaning pollutants on environmental quality is to have environmental data that extend over a period of time, preferably starting from before the CCP began operation. It will be more efficient to study plants where air and water quality data are already in existence.

Tertiary Constraints

There are three desirable criteria which can be applied if several sites are left following application of primary and secondary criteria. These are as follows.

(1) Minimal coal industries in the area. This criterion is intended to minimize the compounding or the confounding of pollution effects by other related industries whose effluents will likely be similar and which may overshadow those of the CCP.

(2) Nonmixed refuse piles. This criterion is intended to enable sampling of segregated solid wastes from the various sizes of cleaned coal, recognizing that the polluting constituents may not be uniformly distributed. Such segregation may be difficult to find.

(3) Homogeneous coal source. To assure that effluents are relatively constant in their chemical characteristics, the ideal situation would be to select plants with a single source of coal of uniform quality. However,

it is recognized that coal seam characteristics vary both laterally and vertically and thus some variability is inevitable. The attempt will be merely to choose plants which receive coals with as uniform quality as possible.

Potential Sampling Locations

An abbreviated list of preparation plants which fits each of the ten site categories (see Table 9) is included in Appendix A along with a summary of their characteristics as reported in the open literature. These 47 potential sampling locations represent the second step in the site selection process and must be condensed through telephone calls and site visits with plant management. The lists in Appendix A should be considered tentative, since process equipment and pyritic sulfur information is not sufficiently detailed in the literature to make positive judgments for all of the sites listed. In addition, the management of the plants on the abbreviated lists have not yet been contacted to determine their willingness to cooperate in a testing program.

Initially, the 400+ coal cleaning plants listed in the 1977 Keystone Coal Industry Manual[4] were separated according to the ten site categories on the basis of the four major variables (i.e., neutralization potential of the soil, pyritic sulfur content of ROM coal, average annual precipitation, and coal cleaning process technology). To shorten this process, it was assumed that all of the sites located in northern Appalachia had a low neutralization potential in the refuse and surrounding soil. Thus, sites in northern Appalachia were considered to have a high pollution potential. All of the other coal cleaning sites in the U.S. were considered to have a high neutralization potential (low pollution potential). This assumption about soil pH is in agreement with the effluent guidelines report.[5]

Data on the pyritic sulfur content of ROM coal were also used to organize facilities according to the ten site categories. This information was obtained from the 1977 Keystone Coal Industry Manual[4] and an EPA report on sulfur in U.S. coals[9]. The best information these two sources could provide is still only an estimate of the pyritic sulfur content of

TABLE 9. SUMMARY OF POTENTIAL SAMPLING LOCATIONS BY SITE CATEGORY(a)

Sampling Option	Site Category	Site Characteristics (N,S,R,T)	Number of Potential Sites(b)
C	1	(1111)	3
	2	(1110)	6
	3	(1011)	11
	4	(0111)	2
B	5	(1010)	3
	6	(0110)	4
	7	(0011)	8
	8	(0010)	4
A	9	(0001)	3
	10	(0000)	3
Total sites to be considered further			47

(a) See Tables 1, 2, and 4 for details on site category and characteristics.

(b) See Appendix A for actual listing of potential sites.

coals actually cleaned by a specific facility. For most facilities, however, this estimate of pyritic sulfur levels should be sufficiently accurate to categorize the ROM coal as either low or high in pyritic sulfur.

Information on process technology which was used to organize cleaning plants according to the ten categories was obtained primarily from the list in the 1977 Keystone Coal Industry Manual[4]. Since this process information was not sufficiently detailed, it was supplemented by information from journal articles and the results of other cleaning plant surveys. These additional sources are reported as footnotes to the lists in Appendix A. However, detailed information was not available for some facilities in any of the articles or surveys. Therefore, some questions about the equipment in use at a particular site were not resolved. For example, the description of equipment at a plant may have indicated that driers were used when it would have been preferable to specify the type of drier, such as centrifugal or thermal.

The initial sorting of the more than 400 known coal cleaning plants using the four variables described earlier resulted in up to 40 facilities listed in some plant categories and as few as two facilities in other plant categories. The large lists were reduced to the more manageable short lists found in Appendix A by imposing several different constraints. The constraints used to select the best plants for sampling purposes include (1) plants cleaning coal from only one seam, (2) plants with a capacity above the mean for that category, and (3) plants not located near coal-fired power plants. This information was available in the literature and did not require a site visit. Verification or investigation of some of the constraints listed in previous sections of this report will require site visits. Lists for some plant categories were already extremely limited in number, so none of the above constraints were used to narrow the lists further. Instead, footnotes were used to indicate the occurrence of undesireable constraints from a sampling viewpoint.

Information Needed for Final Site Selection

Some of the information crucial in the final selection of one sampling site for each site category was not available in the literature. This information must be obtained by site visits to some of the 48 cleaning plants listed in Appendix A. The initial step should be to determine whether the management of these plants will be willing to cooperate in a field sampling program. Site visits should be made to plants where the management has given a positive response to a request for a sampling program. Information that needs to be obtained during these site visits is outlined in Appendix B. On the basis of the information obtained during site visits, a final decision can be made regarding the most appropriate sampling sites.

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(8) Zubovic, P., "Geochemistry of Trace Elements in Coal", Symposium Proceedings Environmental Aspects of Fuel Conversion Technology, EPA 600/2-76-149 (1976).

(9) Cavallaro, J.A., Johnston, M.T., and Deurbrouck, A.W., "Sulfur Reduction Potential of U.S. Coals: A Revised Report of Investigations", EPA 600/2-76-091, Bureau of Mines RI 8118, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (April, 1976), 323 pp.

APPENDIX A

SHORT LISTS OF CANDIDATE SAMPLING SITES BY SITE CATEGORY

TABLE A-1. CANDIDATE SITES FOR SITE CATEGORY 1 (1111)[a]--PENNSYLVANIA

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur, %
Pennsylvania Electric Company	Homer City Cleaning Plant[c]	Homer City/ Indiana				
	Interim Configuration[d]		21,600	Upper Freeport (from 2 mines), Trucked-in coal	Sc-CY-CT-T-W TD-Fil	1.44-4.95 P Avg 2.52 P[g]
	Final Configuration[e]		28,800	Ditto	Add.: HMC-Mag	
Managed by: Consolidation Coal Co. Owned by: National Mines Corporation (subsidiary of National Steel)	Laurel Mine[f]	Reel's Corner/ Somerset	3,300	Lower Kittanning	HMC-F-T-CY-CT-Sc-CD-Fil-Mag-Br	2.47 P[h]
Duquesne Light Co.	Warwick Mine Nos. 2 & 3	Greensboro/ Greene	18,000	Sewickley, Pittsburgh	HMC-CY-CT-T-Fil-Br-Sc-Mag	2.19 P[h]

Footnotes appear on following page.

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Footnotes for Table A-1:

(a) Represents low soil neutralization potential, high pyritic sulfur, high rainfall, and high technology.

(b) Abbreviations for cleaning equipment in Appendix A are as follows: A = air tables, Br = breakers, CD = centrifugal driers, Cr = crusher, CT = centrifuges, CY = cyclones, D = driers, F = flotation units, Fil = filters, H = heavy media washer, HMC = heavy media cyclones, HMV = heavy media vessel, J = jigs, Mag = magnetic separators, PT = pick tables, Sc = screens, T = thickeners, TD = thermal driers, W = washing tables.

(c) See the following articles for additional information:
McConnell, James F., and Statler, Charles W., "Multi-Stream Coal Cleaning Strategy for Control of Sulfur", AIME Transactions, 260 (3), 237-241 (1976).
Anonymous, "Multi-Stream Coal Cleaning System Promises Help With Sulfur Problem", Coal Age (January, 1976).

(d) Equipment used corresponds to a Type F plant.

(e) Equipment used corresponds to a combination of Plant Types F and H.

(f) See the following article for additional information:
Mason, Richard H., "New Laurel Mine Features Refined Preparation Techniques", Coal Mining and Processing (February, 1976).

(g) P = pyritic sulfur; determined from Battelle's analysis of coal from the Helen Mine, Helvetia Mine, and trucked-in-coal sources.

(h) P = pyritic sulfur; determined from Cavallaro, J. A., Johnston, M. T., and Deurbrouck, A. W., "Sulfur Reduction Potential of U. S. Coals: A Revised Report of Investigations", EPA-600/2-76-091, U. S. Burea of Mines RI 8118, U. S. Environmental Protection Agency, Research Triangle Park, North Carolina (April, 1976), 323 pp.

TABLE A-2. CANDIDATE SITES FOR SITE CATEGORY 2 (1110)[a]--Ohio

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
North American Coal Corporation	Powhatan No. 1 Mine	Powhatan Point/ Belmont County	5,000	Pittsburgh (No. 8)	HMV[f]-Br-Sc-Cr-Ct	2.88 P[e]
North American Coal Corporation	Powhatan No. 3 Mine	Powhatan Point/ Belmont County	5,000	Pittsburgh (No. 8)	HMV-Br-Sc-Ct	2.56 P[e]
Central Ohio Coal Company	Muskingum Mine	Cumberland/Noble	11,000	Meigs Creek (No. 9)	J-CT-T-Cr-Br-Sc-Mag	4.7 T
Southern Ohio Coal Company	Meigs Mine No. 1	Athens[d]/Meigs	18,850	Clarion (No. 4-A)	H-CT-T-Fil-Cr-Br-Sc-Mag	2.03 P
Southern Ohio Coal Company	Raccoon Mine No. 3	Athens[d]/Vinton	7,000	Clarion (No. 4-A)	J-CY-CT-T-Fil-Cr-Br-Sc-Mag	2.03 P
Peabody Coal Company	Sunnyhill Mine	New Lexington/Perry	6,000	Middle Kittanning (No. 6)	J-Cr-Sc-D-PT	0.11-3.58 P Avg 1.84 P

(a) Represents low soil neutralization potential, high pyritic sulfur, high rainfall, and low technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) T = total sulfur; P = pyritic sulfur. Sulfur values determined from the following two sources: 1977 Keystone Coal Industry Manual, G. F. Nielsen (Ed.), McGraw-Hill, Inc., New York (1977), 1184 pp. Cavallaro, J. A., Johnston, M. T., and Deubrouck, A. W., "Sulfur Reduction Potential of U.S. Coals: A Revised Report of Investigations", EPA-600/2-76-091, U.S. Bureau of Mines RI 8118, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina (April, 1976), 323 pp.
(d) Located in general vicinity of E. M. Poston Power Plant, RFD 2, Athens, Ohio.
(e) Pyritic sulfur levels reported by North American Coal Corporation.
(f) The HMV at Powhatan No. 1 mine is a chance cone.

TABLE A-3. CANDIDATE SITES FOR SITE CATEGORY 3 (1011)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
		Kentucky (Eastern)				
National Mines Corporation (Sub: National Steel Corp.)	Beaver Creek Div.[d] (Stinson Mines)	Kris/Knott	10,000	Elkhorn No. 3	H-F-CY-CT-T-W-Fil-Cr-Br-Sc-TD-Mag	0.67 P
Blue Diamond Mining	Leatherwood Mine 1	Leatherwood/ Perry	6,000	Leather-wood	H-J-F-CT-T-D-Cr-Br-Fil-Mag-Sc	0.6-0.9 T
		Virginia				
Island Creek Coal Company	Virginia Pocahontas No. 1 Mine	Keen Mountain/ Buchanan	8,000	Pocahontas No. 3	H-F-CT-W-D-Fil-Sc	0.3-0.8 T
	Virginia Pocahontas No. 4 Mine[e]	Keen Mountain/ Buchanan	8,000	Ditto	H-F-CT-W-D-Cr-Sc	0.85 T
Virginia Pocahontas Company	Virginia Pocahontas No. 2 [f]	Keen Mountain/ Buchanan	8,000	Ditto	H-F-CT-W-D-Fil-Cr-Sc-Mag	0.3-0.8 T
Westmoreland Coal Company	Bullitt Mine[e,g]	Big Stone Gap/ Wise	8,000	Dorchester	H-F-CY-CT-T-W-Sc-Mag	0.25 P
		West Virginia				
Itmann Coal Company	Itmann Mine[h,i]	Itmann/Wyoming	12,000	Pocahontas No. 3	H-F-CY-CT-T-W-TD-Fil-Cr-Br-Sc-CD	0.4-1.0 T
Maple Meadow Mining Company	Mine No. 1[j]	Fairdale/Raleigh	6,000	Beckley	HMV-HMC-F-CT-TD-Cr-Mag-T-Sc	0.8 T
Westmoreland Coal Company	Hampton Div. Mine No. 3	Clothier/Boone	5,900	Cedar Grove	H-F-CY-CT-T-W-D-Cr-Br-Sc-PT-Mag-Fil	0.15 P
	Ferrel Mine	Clothier/Boone	8,000	Ditto	H-F-CY-CT-T-W-D-Cr-Br-Sc-Mag-Fil	0.145 P
Southern Ohio Coal Company	Martinka Mine No. 1	Fairmont/Marion	≈8,000	Lower Kittanning	HMV-W-CY-Fil-CT-T-TD-F[k]	2.46T[k]

Footnotes appear on following page.

Footnotes for Table A-3:

(a) Represents low soil neutralization potential, low pyritic sulfur, high rainfall, and high technology.
(b) For definitions of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) For additional information, see the following article:
Sisti, D. C., "Sulfur Removal at Beaver Creek Consolidated Coal Company's Stinson Plant", Society of Mining Engineers, AIME Trans., 258, 95-97 (1975).
(e) See Footnote (d), Table A-2.
(f) For additional information, see the following article:
Valentine, William E., "Preparation Plants for Buchanan County Coal", Mining Congress Journal, pp 53-55 and 58 (September, 1969).
(g) For additional information, see the following articles:
O'Brien, E. J., and Walker, J. L., Jr., "Environmental Layout and Process Innovations in the Bullitt Plant", Mining Congress Journal, pp 37-42 (May, 1973).
Lowman, Stephen G., "Westmoreland Coal's Bullitt Plant Upgrades Steam Coal Quality", Coal Age, 78 (3), 70-75 (March, 1973).
(h) For additional information, see the following articles:
Anonymous, "Consol Preparation ... Quality for All Markets", Coal Age, 69 (10), 158-170 (1964).
Anonymous, "Environmental Protection--A Consol Objective Since 1948", Coal Age, pp 122-126 (October, 1972).
(i) Data available from EPA (Office of Air Programs) study (unpublished).
(j) See flowsheet on pages 312-313 of Keystone Manual. [Reference is on Table A-2, Footnote (c).]
(k) Personal communication with American Electric Power, December, 1977.

TABLE A-4. CANDIDATE SITES FOR SITE CATEGORY 4 (0111)[a]--KENTUCKY (WESTERN)

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
The Pittsburgh & Midway Coal Mining Company	Colonial Mine[d]	Madisonville/ Hopkins	10,000	Nos. 9 and 14	J-CY-W-Cr-Br-CD-Sc	2.89-3.83 P Avg 3.50 P
Peabody Coal Company	Ken, Ken 4, and Ken 4-N Mines	Beaver Dam/ Ohio	10,000	No. 9[e]	H-Cr-Sc-D-PT	1.88 P

(a) Represents high soil neutralization potential, high pyritic sulfur, high rainfall, and high technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) See the following articles for more information:
Jackson, Daniel, Jr., "P&M's Expanded Colonial Mine: Big, Modern, Efficient", Coal Age, 72 (11), 56-65 (1967).
Anonymous, "P&M's Coal Preparation ... Market Directed in Kentucky ... and Farther West", Coal Age, 71 (10), 116-126 (1966).
"Methods and Costs of Coal Refuse Disposal and Reclamation", U. S. Bureau of Mines Information Circular 8576, U. S. Bureau of Mines, Pittsburgh, Pennsylvania (1973), 36 pp.
(e) Plant seam only; data on other coal sources not available.

TABLE A-5. CANDIDATE SITES FOR SITE CATEGORY 5 (1010)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name	Plant Type[b]	Sulfur[c], %
		Kentucky (Eastern)				
Indian Head Mining Company	Mine Nos. 4 and 5	Hazard/Perry	2,500	Hazard No. 7	J	0.7-0.9 T
		Pennsylvania				
Greenwich Collieries	North and South Mines	Edensburg/Cambria	13,000	Lower Freeport	J-Sc-CY-CT	0.34 P
		West Virginia				
Island Creek Coal Company	Elk Creek No. 10[d]	Emmett/Logan	2,500	Cedar Grove	J-Sc	0.36 P

(a) Represents low soil neutralization potential, low pyritic sulfur, high rainfall, and low technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) For additional information, see the following article: Anonymous, "Island Creek ... 'Precisioneered' Coal Preparation", Coal Age, 10 (10), 130-141 (1965).

TABLE A-6. CANDIDATE SITES FOR SITE CATEGORY 6 (0110)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
		Illinois				
Peabody Coal Company	Mine No. 10	Pawnee/Christian	15,500	No. 6	J, Sc	2.55 P
		Kentucky (Western)				
Island Creek Coal Company	Fies Mine[d,e]	Fies/Hopkins	7,000	No. 11	J-CT-Cr-Sc-Br	2.62 P
	Hamilton Mine No. 1[d,e,f]	Morganfield/Union	9,200	No. 9	HMV-CT-Br-Cr-Sc-CY-Mag	2.40 P
	Hamilton Mine No. 2	Ditto	8,400	Ditto	H-CT-Br-Sc	Ditto

(a) Represents high soil neutralization potential, high pyritic sulfur, high rainfall, and low technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) Data available from Effluent Guidelines Survey (unpublished).
(e) Data available from Versar's survey (unpublished).
(f) For additional information, see the following article: Anonymous, "Island Creek ... 'Precisioneered' Coal Preparation", Coal Age, 10 (10), 130-141 (1965).

TABLE A-7. CANDIDATE SITES FOR SITE CATEGORY 7 (0011)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
			Alabama			
Calvert & Marsh Coal Company, Inc.	Berry Mt. Mines	Oneonta/ Blount	1,000-1,600	Rosa	Sc-H-CY-W-Cr	0.65 P
Mead Coal, Industrial Products Group, The Mead Corporation	Mulga Mine	Mulga/ Jefferson	--	Pratt	Cr-Br-Sc-D-H-F-CY-T-Fil	1.4 T
Jim Walter Resources, Inc.	Bessie Mine[d]	Birmingham/ Jefferson	2,600	Mary Lee	Cr-Br-Sc-Mag-HMV-F-CY-W-Fil	0.13 P
	Blue Creek No. 3	Adger/ Jefferson	10,600	Blue Creek	Fil-Br-Sc-Mag-H-F-CT-T-W	0.8 T
	Blue Creek No. 4	Brookwood/ Tuscaloosa	10,000	Blue Creek	Fil-Br-Sc-Mag-H-F-CT-T-W	0.72 P
			Arkansas			
National Mines Corporation (subsidiary of National Steel)	Sugarloaf Mine	Ft. Smith/ Sebastian	≈600	Hartshorne	Br-Sc-Mag-H-CY-Ct-W	1.0 T
			Illinois			
Old Ben Coal Company	Old Ben No. 21[e,f,g]	Sesser/ Franklin	800 tph	No. 6	Br-Sc-HMC-Fil-TO-J-F-CY-CD-A	0.8 P
Freeman United Coal Mining Co. (Div. Material Service Corp.)	Orient Mine No. 3	Waltonville/ Jefferson	14,000	No. 6	H-F-J-Cr-Sc-D-Mag	0.87 P

(a) Represents high soil neutralization potential, low pyritic sulfur, high rainfall, and high technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) For additional information see the following article: Jackson, Daniel, Jr., "Mining and Preparing a High-Reject Seam", Coal Age, 73 (6), 58-67 (1968).
(e) Data available from Effluent Guidelines Survey (unpublished).
(f) Plant flowsheet available from EPA (Office of Air Programs) study (unpublished).
(g) For additional information, see the following article: Anonymous, "New Coal for Midwest Steel", Coal Age, 65 (7), 100-105 (1960).

TABLE A-8. CANDIDATE SITES FOR SITE CATEGORY 8 (0010)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
		Alabama				
Alabama By-Products Corporation	SEGCO No. 1 Mine	Goodsprings/Walker	--	Mary Lee	J	0.7 T
Black Diamond Coal Mining Company	Black Diamond 3 Mine	Bessemer/Jefferson	2,100	Blue Creek	J-Cr	1.0 T
		Illinois				
Monterey Coal Company	Monterey No. 2 Mine	Carlinville/Clinton	--	No. 6	J-CY-CT-Br-Sc	1-4 T
		Washington				
Palmer Coking Company, Inc.	Rogers Mine	Black Diamond/King	--	Franklin No. 10	H	0.6 T

(a) Represents high soil neutralization potential, low pyritic sulfur, high rainfall, and low technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.

TABLE A-9. CANDIDATE SITES FOR SITE CATEGORY 9 (0001)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type[b]	Sulfur[c], %
		New Mexico				
Kaiser Steel Corporation	York Canyon Mine[e]	Raton[d]/Colfax	6,000	York	HMC-HMV-F-CY-CT-T-Fil-Cr-Br-Sc	0.6 T
		Utah				
U.S. Steel Corporation	Wellington Preparation Plant[f]	E. Wellington/Carbon	7,500	Lower Sunnyside	Fil-Cr-Sc-D-H-F-CY-CT	.4-1.09 T
Kaiser Steel Corporation	Central Preparation Plant	Sunnyside/Carbon	9,000	Upper and Lower Sunnyside (from 2 mines)	J-F-CT-T-Fil-Cr-Br-Sc	.09 T

(a) Represents high soil neutralization potential, low pyritic sulfur, low rainfall, and high technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.
(d) Raton Power Plant owned by Raton Public Service Company, is located at P.O. Box 40, Raton, N.M.
(e) For additional information, see the following articles: Heers, R. G., "Coal Handling at York Canyon Mine", Mining Congress Journal, 53 (9), 58-61 (1967). Jackson, Daniel, "York Canyon Researches in Depth for Optimums in Mining, Preparation", Coal Age, 81 (5), 104-109 (May, 1976).
(f) For additional information, see the following articles: Anonymous, "Western District -- Colorado, Utah", Coal Age, 78 (11), 131-136 (1973). von Storch, R. M., "Improving Coking Coal Quality", Coal Age, 64 (2), 112-116 (1959). Anonymous, "Improved Preparation Solidifies Knight Ideal Market Position", Coal Age, 63 (5), 100-105 (1958).

TABLE A-10. CANDIDATE SITES FOR SITE CATEGORY 10 (0000)[a]

Company Name	Mine or Plant Name	Town/County	Capacity, tpd	Seam Name(s)	Plant Type(b)	Sulfur(c), %
		Colorado				
The Imperial Coal Company	Eagle Mine	Erie/Weld	≈1,000	Laramie No. 3	H-CT-Mag-Cr-Sc-PT	0.06 P
		Utah				
Braztah	Braztah Mine Nos. 3, 5	Helper/Carbon	≈2,500	Castle Gate D, Subseam No. 3	H-Cr-Sc-Mag	0.53 T
Plateau Mining Company	Star Point Mine Nos. 1 and 2	Price/Carbon	5,200	Hiawatha, Wattis	H-CY-CT-Fil-Cr-Sc	0.16 P

(a) Represents high soil neutralization potential, low pyritic sulfur, low rainfall, and low technology.
(b) For definition of abbreviations see Footnote (b), Table A-1.
(c) See Footnote (c), Table A-2.

APPENDIX B

COAL PREPARATION PLANT
INFORMATION FORM

TABLE B-1. COAL PREPARATION PLANT INFORMATION FORM

1. Name of Company:_____ Location:_____ Plant Designer:_____ Construction:_____ (Year)

Plant Name:_____ (City) (County)

Mailing Address:_____ (Street) Contact:_____ Telephone No._____

_____ (City) (State) (Zip Code) Plant Code No._____

PLANT DESIGN AND OPERATING DATA

2. Cleaned Coal Tonnage:

Design Capacity:_____ (TPD)_____ (TPY)_____

Operating Capacity:_____ (TPD)_____ (TPY)_____

Normal Operation Schedule:

Hr/day_____

Days/wk_____

Wks/yr_____

			FEED COAL(S)	CLEAN COAL(S)		REFUSE(S)	
3.	SOURCE	Mine(s)					
		District					
		Seam(s)					
		Region					
		Rank					
		Type					
4.	CHEMICAL CHARACTER	Moisture					
		Volatile Matter					
		Ash					
		Fixed Carbon					
		Total Sulfur					
		Btu					
		Pyritic Sulfur*					
		Organic Sulfur					
		Sulfate Sulfur					
		Other (Specify)					
		*This information is very important to the program!					
5.	PHYSICAL CHARACTER	Top Size					
		Bottom Size					
		Free Swelling Index					
		Grindability Index (Hardgrove)					
		Specific Gravity					

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PLANT EQUIPMENT INFORMATION

Name of Company

Plant Code No.

EQUIPMENT	TYPE	DESCRIPTION/MANUFACTURER	NUMBER	FEED COAL SIZE	TONNAGE HANDLED
6. Breaking and Crushing					
7. Sizing, Screening, Blending, Splitting					

PLANT EQUIPMENT INFORMATION

Name of Company: Plant Code No.

EQUIPMENT	TYPE	DESCRIPTION/MANUFACTURER	NUMBER	FEED COAL SIZE	TONNAGE HANDLED
8. Wet Washing					
9. Dewatering					

PLANT EQUIPMENT INFORMATION

Name of Company: Plant Code No.

EQUIPMENT	TYPE	DESCRIPTION/MANUFACTURER	NUMBER	FEED COAL SIZE	TONNAGE HANDLED
10. Dry Concentrators					
11. Driers					

12. Details on Thermal Driers (if present)

(a) Describe the type of fuel used in drier furnace. If coal is used indicate the source.

Furnace operation:

Type Fuel	Type of Firing	Fuel Rate, lb/hr	% Sulfur in Fuel	Caloric Value Btu/lb

(b) Range of Normal Operating Temperatures in System:

Combustion zone: _____ to _____ °F (in furnace)

Fluid bed: _____ to _____ °F (above bed)

_____ to _____ °F (below bed)

(c) Dry Precleaners:

No. of Cyclones/Drier _____

Manufacturer and Type _____

(d) Wet Scrubbers:

No. of Scrubbers/Drier _____

Manufacturer & Type _____

(e) Exhaust System Data:

Design basis, emissions from dry collector; _____ Gr/SCF

[SCF = ft^3 dry air at 70°F, 1 atm pressure]

Design basis, emissions from scrubber outlet; _____ Gr/SCF

(f) Exhaust System:

Exhaust Locations	No.

(g) Sampling Ports: Indicate the location of all sampling ports on the thermal drier and its associated pollution control devices on an attached diagram. Attach the results of previous monitoring efforts on the thermal drier.

13. Facility Diagrams:

(a) Supply schematic representations of the preparation plant and ancillary facilities (e.g., coal conveyors, coal storage areas, refuse disposal areas, settling pond, wastewater treatment facilities, etc.)

(b) Supply sketch or schematic details of any thermal dryer system, including the air pollution control equipment.

14. Refuse Disposal Area:

(a) Describe the type and size of refuse generated from cleaning operations, and indicate whether the sizes are segregated into different piles at the disposal area. _____

_____

_____

(b) Describe the method of waste disposal and type of disposal area (e.g., dump, sanitary landfill, incineration, open burning, salvaged, etc.) _____

(c) Indicate the number of years refuse has been dumped at the disposal area. If more than one dumping area has been used in the past, indicate the age of each separate refuse pile

Age of 1st pile _____ yrs. Age of 2nd pile _____ yrs.

(d) Indicate the name of the refuse dump operator. _____

(e) If soil analyses have been made at the refuse dump area, indicate the average soil pH (i.e., the neutralization potential of the soil). If no data is available on soil pH from the plant, obtain this information from the county Soil Conservation Service.

Soil pH _____ (average)

15. Coal Industries in the Area:

List all coal mining, processing, or burning industries within a 5-mile radius of the coal cleaning plant and estimate the distance of each industry from the plant.

Coal Industries in Area	Distance From Cleaning Plant

16. Availability of Baseline Data:

Do you presently, or have you in the past, monitored air or water quality in the vicinity of the coal cleaning plant or associated facilities (e.g., coal storage pile, refuse disposal area, etc.) ☐ yes ☐ no
If the above answer is yes, please indicate the location of your sampling sites and the parameters measured.

Sampling Locations	Parameters Measured

Please attach example copies of the results of several sampling runs or copies of any summaries of the air and/or water quality monitoring analyses.

Have any environmental assessments (e.g., EIS or NPDES) ever been made of the coal cleaning plant or its associated facilities. ☐ yes ☐ no
If the answer above is yes, please attach copies of these assessments.